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RESOURCE USE EFFICIENCY AMONG FARMERS UNDER TANK REHABILITATION INTERVENTIONS OF *JALA SAMVARDHANE YOJANA* SANGHA (JSYS) IN CHITRADURGA DISTRICT OF KARNATAKA STATE

MANJU, H. C[1], PRAKASH KAMMARDI, T. N[2], SAGAR. M[3] & YOGEESH, K. J[4]

[1,2,3]Department of Agricultural Economics, University of Agricultural Science, G. K. V. K, Bangalore, Karnataka, India

[4]Department of Farm Engineering, Banaras Hindu University, Varanasi, Uttar Pradesh, India

ABSTRACT

The study was conducted in Chitradurga district of Karnataka State to access the importance of Jala Samvardhane Yojana Sangha (JSYS) interventions in rehabilitation of community based tanks. The study was based on the primary data collected from 120 sample respondents for the period 2010-2011. The secondary data was collected from JSYS, Bangalore. The farmers from collective action and action research (CAPAR) and only collective action (CAO) realized more returns per acre in all the crops when compared to control. The technical knowhow from CBPMPCS, Bangalore and infrastructure developed by JSYS helped the farmers in getting better returns. Gross cropped area and water applied were positively significant at 1 per cent and better explained the variation in gross returns and these two were used judiciously and still have a scope to increase for realizing higher returns. Water use efficiency was 92.57 Kg/acre inch in CAPAR in case of maize where as the proportionate change was highest in case of paddy with 38.68 per cent in CAPAR and 26.10 per cent in CAO when compare to control. Return per acre inch of water used was highest incase of green gram in all three scenarios among all crops.

KEYWORDS: Jala Samvardhane Yojana Sangha, Water Use Efficiency, Return per Acre Inch of Water

INTRODUCTION

Tanks are historical innovations to even out the monsoon irregularities and reduce the risks of uncertainties in water availability in the dry zones. The tanks were mainly meant for protective irrigation to the crops. The technology of water use for agriculture has developed over a period of several centuries and its history has grown parallel with the pattern of human settlements and village societies. Therefore the success and failure of the irrigation system depends to a great extent on the active participation of the individual beneficiary in association with community at large. Tanks are common property resources supporting village economy. Some four or five decades ago tanks were the chief sources of rural water needs and the livestock requirements. They also impound silt by the sedimentation, which also can be used to supplement nutrients and improve water holding capacity of soils.

Karnataka, on one hand evinces a critical need for rejuvenation of tank systems to restore their storage capacity and on the other, faces a resource crunch to take up the required repairs and reconstruction of these tank and similar civil structures. Taking the contemporary problems and constraints for efficient management of tanks into account, it was felt that the responsibility of tank management should be handed over back to the local communities as it was there in traditional system of tank management. As a pre-requisite there is need for systematic rehabilitation of the entire tank infrastructure before handing over to the community, which obviously calls for huge investment. The government of

Karnataka has, therefore, approached the World Bank for assistance to take up the tank rehabilitation programme in the state. It is in this background, the Karnataka Community Based Tank Management Project (KCBTMP) has been started on a pilot basis, during the year 2002-03 with the financial assistance from the World Bank.

Jala Samvardhana Yojana Sangha (JSYS)

It was established as a nodal agency to promote this task in the state under the Department of Minor irrigation in June 2002. Tanks have been the symbol of water harvesting tradition in Karnataka since centuries. There are about 36,672 tanks in Karnataka. Tank systems have contributed to the sustainability of ecology, environment and rural livelihoods since centuries. The tank system with a potential to irrigate 6, 90, 000 ha of the command area acts as a major contributor for stabilization of groundwater status in majority of semi-arid zones of the state that are in despair due to lack of management resulting in physical degradation and declined operational performance. JSYS has the responsibility of forming peoples' committee towards rehabilitation of tanks as social institutions to rehabilitate and hand over them to the target tank users. By adopting a participatory system, JSYS intends to promote and organize the activity of the capacity building as well as providing logistic support. JSYS plans to seek the help of NGOs for training and orientation of the target tank users. JSYS has moved from desiltation to Integrated Tank Development. KCBTMP was launched in nine districts of Karnataka state comprising Bidar, Bellary, Raichur, Tumkur, Kolar, Chitradurga, Koppala, Bagalkot and Haveri. (UAS) Bangalore and Dharwad have been given the responsibility of enhancing agriculture productivity and improving water use efficiency in the districts coming under their respective operational jurisdictions.

METHODOLOGY

Chitradurga is one among the ten districts selected by JSYS for intervention under tank rehabilitation. So, Chitradurga was purposively selected for the present study as a major portion of its cultivable land depends on rainfall for agriculture, which is of about 85 percent and irrigation accounts for only 15 percent of the cultivable area. The JSYS interventions are being taken up in all the six taluks of Chitradurga district. About 120 sample respondents were selected for the study. There were three scenarios of intervention, so 40 sample respondents were selected representing each scenario. The first scenario had both collective action and action research (CAPAR), second scenario had only collective action (CAO) and third scenario was control.

Primary information for the reference period 2010-2011 was collected by using pre-tested interview schedule, applying face–to-face interview method. For evaluating the objectives of the current investigation, the analytical techniques used are summarized as below.

Resource Use Productivity and Allocative Efficiency of Major Crops - Cobb-Douglas Production Function

The Cobb-Douglas type of production function has been the most popular of different algebraic forms of production functions available, as it provides a compromise among (i) adequate fit to the data, (ii) computational simplicity, and (iii) sufficient unused degrees of freedom for statistical testing. One of its serious limitations is that it accommodates constant/ increasing/decreasing marginal productivity and does not allow an input-output curve embracing all the three relationships. Despite this limitation, it has the greatest use in diagnostic analysis as the regression parameters represent the elasticities and reflect the marginal productivity at the geometric mean level of the inputs and the output. Because of such overwhelming advantages over the other forms, Cobb-Douglas type of production function was employed in this study.

The specific Cobb-Douglas type of production function used for the study was:

$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4}$ ………………………………………………………………….……………………(1)

Where,

Y = Gross returns (Rs./farm)

a = Intercept, a scale parameter

X_1 = Gross cropped area (acre/farm)

X_2 = Labour (men & women) (Rs/farm)

X_3= Capital (material cost, bullock & machine labour) (Rs/farm)

X_4= water applied (hectare centimeter/farm)

b_i = Output elasticities of respective inputs. The summation of these gives returns to scale.

The equation (1), upon logarithmic transformation takes the linear form. The parameters were estimated using the Ordinary Least square (OLS) method.

$\text{Log } y = \text{Log } a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4$ …………………………...…………… ………… (2)

Adjusted R^2 (the coefficient of adjusted multiple regression) was computed to test the goodness of fit of the model.

$$t = \frac{b_i}{\text{Standard error of } b_i} \quad \text{……… …… (3)}$$

The regression coefficients (b_i) were tested for the significance using't' test.

The allocative efficiency or price efficiency is an economic measure as against technical efficiency, which is a physical measure. A production activity is allocatively efficient when the value of the marginal product (VMP) of a factor is equal to the marginal factor cost (MFC).

The Cobb-Douglas type of production function fitted for major crops of both project beneficiary and control farmers were used to compute the allocative efficiencies. The first differential itself was the VMP of the factor as the dependent variable was the gross return from cultivation of crops in the farm. Since all the independent variables in regression are the cost of inputs, the MFC of factors except land and water applied was unity. To arrive at the MFC value of land its rental value was calculated. To arrive at the MFC of water applied cost per hectare centimeter of water applied was calculated. Thus, the allocative efficiency measure of all factors are given by the equation

$$\text{Allocative efficiency} = \frac{VMP_{Xi}}{MFC_{Xi}} \quad (4)$$

Where, $VMP_i = MPPi * P_{xi}$

$$MPP_i = b_i \frac{Y}{X_i} \qquad \text{……}(5)$$

VMP_i = Value marginal product of i^{th} input

b_i = input co-efficient of i^{th} input

The value marginal product of the inputs was worked out by multiplying the respective input co-efficient with the geometric mean level of output and divided by the geometric mean level of respective input.

Allocative efficiency equal to unity represents the most efficient allocation while less than or more than unity represents over or under use of the factor respectively.

Water Use Efficiency

Water use efficiency may be defined as crop production per unit amount of water used. In economic meaning the value of product(s) produced per unit of water volume consumed. The term water use efficiency originates in the economic concept of productivity measures the same amount of any given resource that must be expended to produce one unit of any goods or service. Thus water productivity might be assured by the volume of water taken into a plant to produce a unit of the output. In general lower the resource input requirement per unit, the higher the efficiency

To calculate the water use efficiency in the study area some of the thumb rules were used for water measurement. Since the data was collected for the period of 2010-2011, the real time measurement of the water used was not possible. So as a thumb rule it is considered that 2 inch depth of water is used per irrigation for semi irrigated crops. It is considered to be 3 inch depth of irrigation water was used per irrigation if the paddy was cultivated under traditional method.

The data on protective/supplementary irrigations given to the crops apart from rainfall is collected from the farmers separately for individual crops. We will get total quantity of water additionally applied to the crop by multiplying total number of irrigations to the height/depth of water per irrigation. This product is further multiplied by the area and crop to which it is applied thereby finally arriving at the total volume of water used for that crop. The area is converted to per-acre basis for comparison between the crops. In order to include the rainfall component in the depth of water irrigated, 50 percent of the rainfall received in that particular area is being considered in calculating the water use efficiency as it is assumed that only that proportion is utilized by the crop. Remaining 50 percent is considered to be unavailable to the crop and prone to some losses such as runoff, seepage etc. For this purpose the rainfall data from the nearest rain guage station is considered to account the depth of water irrigated by rainfall. The rainfall data for the particular cropping period is summed up over months for different crops separately corresponding to its duration. Only 50 percent of this total rainfall is accounted in calculating the water use efficiency since rest 50 percent may go as a loss which the crop cannot use. Totally adding up the component of rainfall and the additional water applied through irrigation gives us the total water used. Dividing the crop output in kilograms per acre by the water used in acre inches for that crop would give the water use efficiency for that particular crop.

$$\textit{Water use efficiency} = \frac{\text{Output produced in kilograms per acre}}{\text{Water used in acre inches}}$$

Additional Water Applied through Irrigation (Centimeters)= Frequency of irrigation * depth of irrigation

Total Water Used By the Crop (Acre Inches)=(water through irrigation + 50 percent of rainfall in the cropping period)* area in acres

RESULTS AND DISCUSSIONS

Resource Productivity

In the present study cobb-douglas type of production function was used to estimate the resources productivity of crops from three intervention scenarios. In order to determine whether the factors of production were used optimally, the efficiency of the allocation of the resources was studied by comparing the marginal value of product with opportunity cost of each of the factors of production.

- **Resource Productivity of Farmers from Three Scenarios Pooled**

The estimated function is presented below.

$Y = 7.22\, x_1^{0.69} x_2^{0.13} x_3^{0.11} x_4^{0.13}$

Table 1: Regression Analysis of Cob-Douglas Production Function of Three Scenarios Pooled

Regressors	Coefficients	t Stat
Intercept	7.22*	19.95
Gross cropped area (X_1)	0.69*	13.21
Labour (X_2)	0.13	1.80
Capital (X_3)	0.11	1.66
Water applied (X_4)	0.13*	4.86
R Square, n=120 farmers	0.91*	
Adjusted R Square	0.91	
∑ bi	1.08	
F-value	327.66	

*Significant At 1 per Cent

An examination of regression coefficients above, which are also elasticities of production, revealed that all the variables such as gross cropped area, labour, capital and water applied have positive relationship with the dependent variable gross return. Further the variables gross cropped area and water applied which had elasticity coefficients of 0.69 and 0.13 respectively were significant at one per cent level. The other two variables such as labour and capital had elasticity coefficients of 0.13 and 0.11 respectively. A one per cent increase in the use of gross cropped area, labour, capital and water applied would increase the gross return by 0.69, 0.13, 0.11 and 0.13 per cent respectively. The coefficient of multiple determination (R^2) was 0.91 for the farmers from three scenarios of intervention. This indicated that the variables included in the function explained 91 per cent of variation in the gross return of farmers. The sum of elasticity coefficients was 1.08 and it was not significant from unity. This indicated constant returns to scale.

- **Resource Productivity of Farmers From Collective Action Plus Action Research Scenario**

The estimated function is presented below.

$Y = 9.12x_1^{0.70} x_2^{0.12} x_3^{0.11} x_4^{0.11}$

The regression results of all three scenarios are presented in Table 2. In CAPAR scenario the variables gross cropped area and water applied which had elasticity coefficients of 0.70 and 0.11 respectively were significant at one per

cent level. The other two variables such as labour and capital had elasticity coefficients of 0.12 and 0.11 respectively. The coefficient of multiple determination (R^2) was 0.98 for the farmers from CAPAR scenario. The sum of elasticity coefficients was 1.06 and it was not significant from unity.

Table 2: Regression Analysis of Cob-Douglas Production Function of Three Scenarios

Regressors	Capar	Cao	Control (Coefficients)
Intercept	9.12	7.11	7.78
	(13.07)*	(8.80)	(13.78)*
Gross cropped area (X_1)	0.70	0.60	0.77
	(9.74)*	(6.46)*	(6.89)*
Labour (X_2)	0.12	0.03	0.08
	(0.82)	(0.21)	(0.95)
Capital (X_3)	0.11	0.24	0.09
	(1.17)	(1.60)	(1.02)
Water applied (X_4)	0.11	0.12	0.08
	(3.02)*	(1.86)	(1.40)
R Square,	0.98	0.89	0.89
Adjusted R Square	0.92	0.88	0.87
n	34	33	36
∑ bi	1.06	1.00	1.03
F-value	118.69	76.13	71.08

*****Significant At 1 per Cent,

Note: CAPAR = Collective Action Plus Action Research; CAO = Collective Action Only

- **Resource Productivity of Farmers from Collective Action Only Scenario**

The estimated function is presented below.

$$Y = 7.11x_1^{0.60}x_2^{0.03}x_3^{0.24}x_4^{0.12}$$

In CA0 scenario gross cropped area had elasticity coefficients of 0.60 and significant at one per cent level. The other three variables such as labour, capital and water applied had elasticity coefficients of 0.03 and 0.24 and 0.12 respectively. The coefficient of multiple determination (R^2) was 0.89 for the farmers from CAO scenario. This indicated that the variables included in the function explained 89 per cent of variation in the gross return of farmers.

- **Resource Productivity of Farmers from Control Scenario**

The estimated function is presented below.

$$Y = 7.78x_1^{0.77}x_2^{0.08}x_3^{0.09}x_4^{0.08}$$

In control, only gross cropped area was significant positively with a coefficient of 0.77 at one per cent level. The other three variables such as labour, capital and water applied had elasticity coefficients of 0.08 and 0.09 and 0.08 respectively. The coefficient of multiple determination (R^2) was 0.89 for the farmers from CAO scenario. This indicated that the variables included in the function explained 89 per cent of variation in the gross return of farmers.

- **Allocative Efficiency of Resources**

The results of MVP/MFC ratios of the sample farmers from three scenarios pooled are presented in Table 3. The ratio of marginal value of product (MVP) to marginal factor cost (MFC) was more than unity in case of gross cropped

area (1.09). The marginal factor cost for land has been worked out as 1/6th of gross revenue which is equal to fair rent or rental value of land. The ratio of MVP/MFC was less than unity in case of labour (0.66), capital (0.43) and water applied (0.96).

Table 3: Allocation Efficiency of Resources for Farmers from Three Scenarios Pooled

Variables	Geometric Mean	Marginal Value Product	Marginal Factor Cost	Ratio of MVP to MFC
Gross cropped area (x1)	5.02	13500.64	12366.85	1.09
Labour (x2)	20066.31	0.66	1.00	0.66
Capital (x3)	26714.33	0.43	1.00	0.43
Water applied (x4)	83.90	156.74	163.00	0.96

The MVP/MFC ratio indicates that an investment of one rupee on land over and above geometric mean levels would increase the gross return by Rs 1.09. Hence there is a scope for increasing area under crops over and above the geometric mean level to increase the gross income.

Table 4: Allocation Efficiency of Resources for Farmers from Collective Action plus Action Research Scenario

Variables	Geometric Mean	Marginal Value Product	Marginal Factor Cost	Ratio of MVP to MFC
Gross cropped area (x1)	4.42	16367.46	13206	1.23
Labour (x2)	19566.00	0.66	1	0.66
Capital (x3)	24567.00	0.49	1	0.49
Water applied (x4)	76.80	151.81	141	1.07

In case of CAPAR scenario, (Table 4) ratio of marginal value product (MVP) to marginal factor cost (MFC) was more than unity in case of gross cropped area (1.23) and water applied (1.07) where as it was less than unity in case of labour (0.66) and capital (0.49). The critical input water was used optimally in this case hence the ratio was more than unity and the water applied was optimum. The MVP/MFC ratio indicates that an investment of one rupee on these inputs such as gross cropped area and water applied over and above geometric mean levels would increase the gross return by Rs 1.23 and Rs 1.07 respectively. Hence there is a scope for increasing gross cropped area and water applied over and above the geometric mean level to increase the gross income.

In case of CAO (Table 5) MVP/MFC ratio was more than unity in case of gross cropped area (1.03) where as less than unity in case of labour (0.14), capital (0.86) and water applied (0.90). land was used optimally and still there a scope to increase area under gross cropped area where as ratio for water was less than unity but it was 0.90 so, the water use was better than control where the ratio was only 0.48. The MVP/MFC ratio indicates that an investment of one rupee on gross cropped area over and above geometric mean levels would increase the gross return by Rs 1.03. Hence there is a scope for increasing gross cropped area over and above the geometric mean level to increase the gross income where as in case of labour, capital and water applied were already used more than the optimum.

Table 5: Allocation Efficiency of Resources for Farmers from Only Collective Action

Variables	Geometric Mean	Marginal Value Product	Marginal Factor Cost	Ratio of MVP to MFC
Gross cropped area (x1)	4.95	11857.47	11485	1.03

Labour (x2)	21456.00	0.14	1	0.14
Capital (x3)	27869.00	0.86	1	0.86
Water applied (x4)	82.40	145.39	160.6	0.90

In case of control scenario it could be observed from the Table 6 that the ratio of marginal value of product (MVP) to marginal factor cost (MFC) was more than unity in case of gross cropped area (1.14). The ratio of marginal value of product (MVP) to marginal factor cost (MFC) was less than unity in case of labour (0.35), capital (0.30) and water applied (0.48). The MVP/MFC ratio indicates that an investment of one rupee on gross cropped area over and above geometric mean levels would increase the gross return by Rs 1.14.

Table 6: Allocation Efficiency of Resources for Farmers from Control Scenario

Variables	Geometric Mean	Marginal Value Product	Marginal Factor Cost	Ratio of MVP to MFC
Gross cropped area (x1)	5.15	12762.98	11123	1.14
Labour (x2)	20689.00	0.35	1	0.35
Capital (x3)	26451.00	0.30	1	0.30
Water applied (x4)	84.60	79.97	165.4	0.48

Water Use Efficiency

A unit of output produced per unit of water used by the crop is termed as water use efficiency. The results of water use efficiency of major six crops of the study area are given below.

The water use efficiency of the farmers from CAPAR was highest for all major crops. The water use efficiency was more because of the technologies given by the JSYS and CBTMPCS on the judicious use of resources including water. The farmers from CAPAR scenarios were more adopted and realized the importance of judicious use of water. Water use efficiency was highest for maize in all the scenarios with 92.57 Kg/acre inch in CAPAR, then 83.52 Kg/acre inch in CAO and only 70.28 Kg/acre inch in case of control where there was no collective action and action research. With regard to paddy water use efficiency was highest in CAPAR Since the farmers from CAPAR and CAO had the demonstrations in their farms and attended the training programmes, workshops, study tours and they adopted the yield improvement technologies etc so, they better had the knowledge of water management and judicious use of resources. Because of above all reasons the water use efficiency was higher in CAPAR and CAO scenario than in control. In case of paddy the water use efficiency was higher in CAPAR with 66.39, then in CAO with 60.37 Kg/acre inch where as in control it was only 47.87 Kg/acre inch. This was because of the above mentioned reasons and the demonstrations on arable crop, water management on paddy and ragi helped the farmer in realising better yield along with increased water use efficiency. In the same way all these technologies helped the farmer in getting higher yield and increased water use efficiency in other crops which are enlisted in the table 7. Proportionate change of water use efficiency was highest in paddy crop with 38.68 per cent more efficient in CAPAR than control. In CAO it was 26.10 per cent. Because of the demonstrations on paddy and ragi made the farmers from CAPAR and CAO scenario to use the water efficiently. The water use efficiency for coconut was highest in case of CAPAR because more drip irrigation was adopted than in other two scenarios of intervention such as only CAO and control.

Table 7: Water Use Efficiency of Major Crops in Three Scenarios

Crops	CAPAR				CAO				control		
	Yield (Kgs/acre)	Water used (acre inches)	WUE (Kgs/acre inch)	Proportionate change from control	Yield (Kgs/acre)	Water used (acre inches)	WUE (Kgs/acre inch)	Proportionate change from control	Yield (Kgs/ acre)	Water used (acre inches)	WUE (Kgs/acre inch)
Paddy	2286	34.43	66.39	38.68	2248	37.24	60.37	26.10	2179	45.52	47.87
Ragi	1138	14.27	79.76	21.13	1082	14.74	73.39	11.46	1042	15.82	65.85
Maize	1756	18.97	92.57	31.71	1660	19.88	83.52	18.83	1610	22.91	70.28
Sunflower	604	17.54	34.44	16.22	584	18.27	31.97	7.87	557	18.79	29.64
Green gram	324	11.73	27.62	19.06	303	11.98	25.29	9.02	297	12.80	23.20
Coconut (Nuts)	4494	36.48	123.18	9.93	3968	34.63	114.59	2.26	4065	36.28	112.05

Note: CAPAR = Collective Action Plus Action Research; CAO = Collective Action Only

- **Returns per Acre Inch of Water Used**

The results of the returns per acre inch of water used are mentioned in the Table 8. The farmers from first two scenarios had better knowledge of water management practice along with judicious use of resources. Since the farmers from first scenario had the demonstration plots on their fields there was better adoption of technologies. In case of CAPAR scenario green gram gave maximum returns of Rs 1104.80 per acre inch of water used, in CAO returns of Rs1011.60and in control scenario it was Rs928. The return from green gram was higher than control by 19.05 per cent in case of CAPAR and it was higher by 9 per cent in case of CAO. Sunflower stood at second position in terms of the returns per acre inch of water used with Rs 1033.05 in case of CAPAR, Rs 958.85 in only CAO and Rs 889.01 in control scenario. Lowest was paddy among major crops of study area which gave only Rs 697.17 in case of CAPAR, Rs633.82 in case of only CAO and Rs 502.73 in case of control. Water use efficiency was higher by 38.68 per cent in CAPAR when compared to control for paddy crop and it was higher by 26.07 per cent in case of CAO. Even though paddy gave less return per acre inch of water used but the proportionate change was highest in paddy than all the crops. Naturally maize also gave good returns per acre inch of water used and the return was Rs 879.58 in CAPAR scenario and Rs 793.60 in CAO scenario where as it was Rs 667.63 in case of control. Water use efficiency was higher by 31.75 per cent in CAPAR than control for maize crop and it was higher by 18.87 per cent in case of CAO than control. Ragi gave a fair returns of Rs 757.75 in CAPAR and Rs 697.12 in CAO where as it was Rs 625.61 in case of control. Majority of ragi was grown as rainfed crop and there was demonstration on ragi crop in the farmer fields and the technologies such as line sowing, irrigation at critical stages etc helped in realizing better returns.

Table 8: Returns per Acre Inch of Water Used Among Major Crops

Crops	CAPAR (Rs/Hacm)		CAO (Rs/Hacm)		Control (Rs/Hacm)
	Return Per Acre Inch	Proportionate Change from Control	Return Per Acre Inch	Proportionate Change from Control	Return per Acre Inch
Paddy	697.17	38.68	633.82	26.07	502.73
Ragi	757.75	21.12	697.12	11.43	625.61
Maize	879.58	31.75	793.60	18.87	667.63
Sunflower	1033.05	16.20	958.85	7.86	889.01
Greengram	1104.80	19.05	1011.60	9.00	928.00
Coconut	739.08	9.93	687.46	2.25	672.33

Note: CAPAR = Collective Action Plus Action Research; CAO = Collective Action Only

SUMMARY AND CONCLUSIONS

Water use efficiency was higher by 31.75 per cent in CAPAR than control for maize crop and it was higher by 18.87 per cent in case of CAO than control. Proportionate change of water use efficiency was highest in paddy crop with 38.68 per cent more efficient in CAPAR than control. In CAO it was 26.10 per cent. Because of the demonstrations on paddy and ragi made the farmers from CAPAR and CAO scenario to use the water efficiently. The water use efficiency for coconut was highest in case of CAPAR because more drip irrigation was adopted than in other two scenarios of intervention such as only CAO and control. Ragi gave a fair returns of Rs 757.75 in CAPAR and Rs 697.12 in CAO where as it was Rs 625.61 in case of control. Majority of ragi was grown as rainfed crop and there was demonstration on ragi crop in the farmer fields and the technologies such as line sowing, irrigation at critical stages etc helped in realizing better returns. The farmers from collective action and action research (CAPAR) and only collective action (CAO) realized more returns per acre in all the crops when compared to control. The technical knowhow from CBPMPCS, Bangalore and infrastructure developed by JSYS helped the farmers in getting better returns. Gross cropped area and water applied were positively significant at 1 per cent and better explained the variation in gross returns and these two were used judiciously and still have a scope to increase for realizing higher returns. Water use efficiency was 92.57 Kg/acre inch in CAPAR in case of maize where as the proportionate change was highest in case of paddy with 38.68 per cent in CAPAR and 26.10 per cent in CAO when compare to control. Return per acre inch of water used was highest incase of green gram in all three scenarios among all crops.

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